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New records of *Lepraria* and *Pyrenula* from China

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Abstract—As a result of our study, two species of *Lepraria* (*L. atlantica*, *L. lobata*) and two species of *Pyrenula* (*P. duplicans*, *P. subelliptica*) are reported for the first time from China, and *Pyrenula pyrenuloides* is reported for the first time from Guizhou province.

Key words—Asia, lichen-forming fungi, taxonomy

Introduction

Lepraria Ach. (*Stereocaulaceae, Ascomycota*), a genus with a worldwide distribution, comprises morphologically simple lichen-forming fungi that never develop fruiting bodies (Orange 2001). Most species have a leprose, sterile thallus with a surface composed of granules. *Lepraria* taxonomy is largely based on the chemistry of secondary metabolites as these lichens produce a wide variety of lichen substances, and other characters are often scarce (Saag & al. 2009). A combination of morphological, chemical, and ITS and mtSSU sequence analyses have been used to investigate this genus (Lendemer & Hodkinson 2013). Also, Lendemer (2011) introduced a standardized morphological terminology and descriptive scheme that should facilitate specimen identification and description preparation.

Pyrenula Ach. (*Pyrenulaceae, Ascomycota*) comprises crustose lichens typically growing on smooth, shaded bark (Aptroot 2012). The

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genus is characterized by perithecioid ascomata, occasionally inspersed hamathecia, unbranched filaments, and distoseptate or (sub)muriform brown mature ascospores. *Pyrenula* encompasses at least 211 species worldwide (Aptroot 2012; Aptroot & al. 2012, 2013, 2014, 2015; Aptroot & Common 2017; Cáceres & al. 2013; Lima & al. 2013; Mendonça & al. 2016; Wijeyaratne & al. 2012). The availability of a world key to the genus (Aptroot 2012) has made it much easier to recognize undescribed taxa.

The purpose of our study is to enrich knowledge of the species composition of *Lepraria* and *Pyrenula* in China, contributing fundamental data and reliable results for the preparation of a Lichen Flora of China. In this paper, we identify four species new to the country—*Lepraria atlantica*, *L. lobata*, *Pyrenula duplicans, P. subelliptica*—and report *P. pyrenuloides* for the first time from Guizhou province.

Materials & methods

The specimens studied are preserved in Lichen Section of Botanical Herbarium, Shandong Normal University, Jinan, China (SDNU). Morphological characters of the specimens were examined under a COIC XTL7045B2 stereomicroscope and an Olympus CX41 polarizing microscope and the lichens were photographed using Olympus SZX16 and BX61 microscopes with an Olympus DP72 digital camera. Sections were mounted in tap water (unless otherwise indicated), and all measurements were made in water or diluted KOH. Lichen substances were identified using standardized thin layer chromatography (TLC) techniques with system C (Orange & al. 2010).

Taxonomy

Lepraria atlantica Orange, Lichenologist 33: 462 (2001) Fig. 1a, b

Morphology—Thallus crustose, leprose (thalli continuous or sometimes diffuse), grey to pale whitish grey, consisting of loosely to densely packed granules, hyphae absent or very short (20–40 µm) in the marginal granules; prothallus absent; hypothallus present, usually forming a thin continuous layer underneath the granules; rhizohyphae absent. Granules globose, ecorticate, (40–)50–60(–80) µm diam., well organized and discrete, remaining distinct and forming compound units. Photobiont green, cells globose, 7.5–15 µm diam. Substrate bryophyte.

Chemistry—Thallus K+ yellow, C–, KC–, Pd+ yellow. Porphyrilic acid detected by TLC.

Specimens examined: **CHINA**. **Qinghai, Huzhubeishan National Forest Park**, Yaoshuiquan waterfall, alt. 2830m, on bryophyte, 19 Aug. 2007, Y.D. Du 20072234 (SDNU); 109 national highway, Xiangpishan, alt. 3520 m, on bryophyte , 15 Aug. 2007, Y.D. Du 20071952 (SDNU).

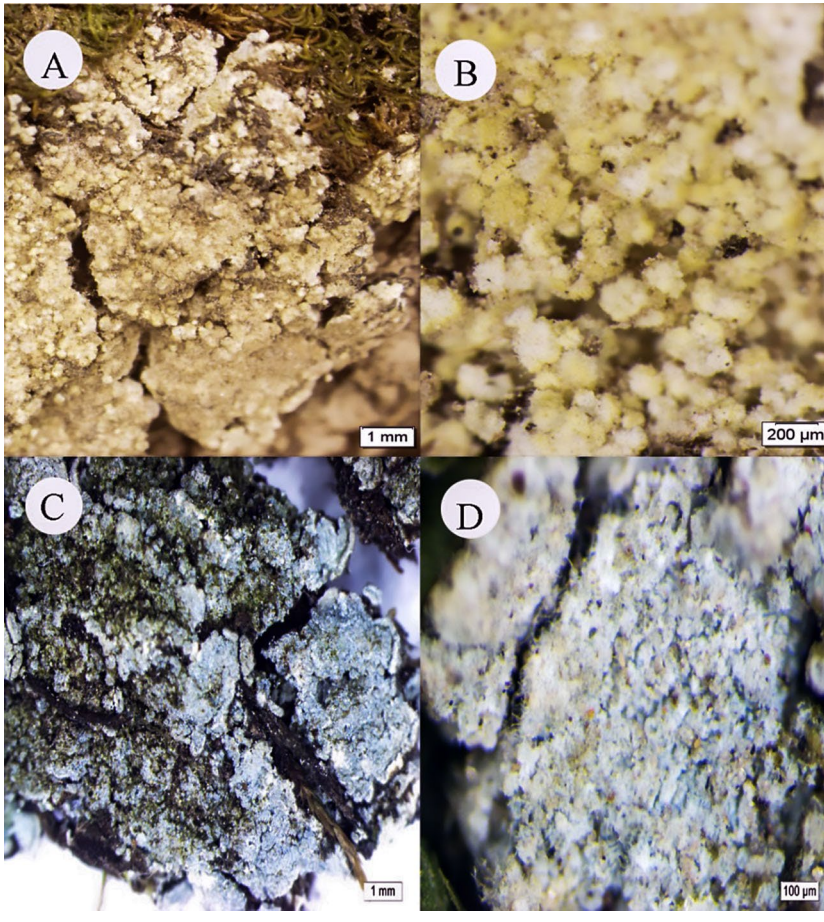

Fig. 1 ***Lepraria atlantica*** (20071952, SDNU). A: thallus; B: granules. ***Lepraria lobata*** (20160512, SDNU). C: thallus and margin; D: granules. Scale bars: A, C = 1 mm; B, D = 200 µm.

Distribution—Wales, the Scottish Highlands, Northwest Ireland, Norway, Australia, Greenland (Orange 2001, Saag & al. 2009, Smith & al. 2009). New to China.

Comments—*Lepraria atlantica* is chemically similar to *L. cacuminum*, which differs by its coarsely granular thallus (Orange 2001), and morphologically similar to *L. jackii*, which differs by not producing porphyrilic acid (Orange 2001, Saag & al. 2007). Our Chinese specimens closely match the protologue description (Orange 2001).

Lepraria lobata Elix & Kalb, Mycotaxon 94: 220 (2006) Fig. 1c, d

Morphology—Thallus crustose, leprose, placodioid, whitish grey to pale greenish grey, margin delimited, forming thin to thick ±continuous extensive irregularly spreading lobes; hyphae hyaline, 25–30 µm long, few surrounding the granules and anchoring the granules tightly to one another; prothallus absent; hypothallus present, usually forming a thin continuous layer underneath the granules; rhizohyphae rarely present. Granules globose, ecorticate, (20–)40–50(–70) µm diam., abundant. Photobiont green, cells globose, 7.5–12.5 µm in diam. Substrate bark.

Chemistry—Thallus K+ yellow, C–, KC+ yellow, Pd–. Atranorin, zeorin, and unknown fatty acid detected by TLC.

Specimens examined: **CHINA**. **Shandong Mt. Lushan**, Guanyunfeng, alt. 695m, on bryophyte, 25 Jun. 2016, X.X. Zhao 20160512 (SDNU); **Guizhou. Tongzi**, Mt. Shixizhenbaizhi, Dongwan to Tiedingba, alt. 2050m, on bark, 25 Jul. 2016, W.C. Wang 20160343 (SDNU).

Distribution—Australia, South Korea (Saag & al. 2009, Joshi & al. 2010). New to China.

Comments—*Lepraria lobata* is chemically similar to *L. pallida*, which is distinguished by a green thallus and gray to black hypothallus rather than rhizohyphae (Joshi & al. 2010). Our Chinese specimens closely agree with the protologue description, except that the holotype lacks a hypothallus (Saag & al. 2009).

Pyrenula duplicans (Nyl.) Aptroot, Biblioth Lichenol. 97: 102 (2008) Fig. 2a–c

Morphology—Thallus corticate, smooth, yellowish to olive green, with white pseudocyphellae. Perithecia mostly simple, only aggregated (as if by chance) when crowded, erumpent from the substratum, covered by thallus, 0.5–1.0 mm diam. Perithecial wall ≤200 µm thick. Ostiole pale, apical. Hamathecium not inspersed with oil droplets, filaments unbranched. Ascospores 2/ascus, grey brown, densely muriform with 9–11 primary septa, ellipsoid with rounded ends, 110–115 × 25–27.5 µm, lumina rounded to somewhat angular. Substrate bark.

Chemistry—No chemical substances detected by TLC.

Specimen examined: **CHINA**. **Guizhou, Jiangkou,** Guanhexiang, Leijiayan, alt. 850 m, on bark, 2 Apr. 2016, X.X. Zhao 20160698 (SDNU).

Distribution—Pantropical (Aptroot 2012). New to China.

Comments—*Pyrenula duplicans* is characterized by its thallus bearing white pseudocyphellae, apical ostiole, non-inspersed hamathecium, and large

muriform ascospores. Our Chinese specimen is similar to the protologue description, except that the holotype has longer (115–180 μm) ascospores (Aptroot 2012).

Pyrenula pyrenuloides (Mont.) R. C. Harris,
Mem. New York Bot. Gard. 49: 99 (1989) Fig. 2d–g

Morphology—Thallus corticate, smooth, pale brownish to olive green, with white pseudocyphellae. Perithecia mostly simple, only aggregated as if by chance when crowded, subglobose, erumpent from the substratum, sides often partly covered by thallus, 0.5–0.9 mm diam. Perithecial wall with crystals, ≤200 μm thick. Ostiole pale, apical. Hamathecium not inspersed with oil droplets, filaments unbranched. Ascospores 8/ascus, grey brown, biseriate in the ascus, muriform with 7–10 rows of 3–8 locelli, fusiform with rounded ends, 50–55 × 12.5–17.5 μm, lumina rounded to somewhat angular. Substrate bark.

Chemistry—No chemical substances detected by TLC.

Specimens examined: **CHINA**. **Guizhou, Leishan,** Mt. Leigongshan, alt. 1160 m, on bark, 1 Nov. 2009, Q. Tian 20102751, 20102817, 20102945 (SDNU).

Distribution —Pantropical (Aptroot 2012). New to Guizhou province, but previously reported from Hongkong (Aptroot & Seaward 1999).

Comments—*Pyrenula pyrenuloides* is characterized by the thallus with white pseudocyphellae, apical ostiole, non-inspersed hamathecium, small muriform ascospores and the central part of the ascospore with more than six lumina between two primary septa. *Pyrenula pyrenuloides* is closely related to *P. papillifera*, but the latter has pointed ends ascospores (Aptroot 2012). Our Chinese specimens closely match the protologue description (Aptroot 2012).

Pyrenula subelliptica (Tuck.) R.C. Harris, Bryologist 90 : 164 (1987) Fig. 2h–k

Morphology—Thallus corticate, whitish to pale brown, without pseudocyphellae. Perithecia solitary, subglobose, erumpent from the substratum, sides scarcely covered by thallus, 0.3–0.5 mm diam. Ostiole pale, apical. Hamathecium inspersed with hyaline oil globules, filaments unbranched. Ascospores 8/ascus, grey brown, 3-septate, fusiform with rounded ends, 30–35 × 10–12.5 μm, angular lumina in a straight line, terminal lumina separated from the exospore by an endospore layer, central lumina strongly elongated. Substrate bark.

Chemistry—No chemical substances detected by TLC.

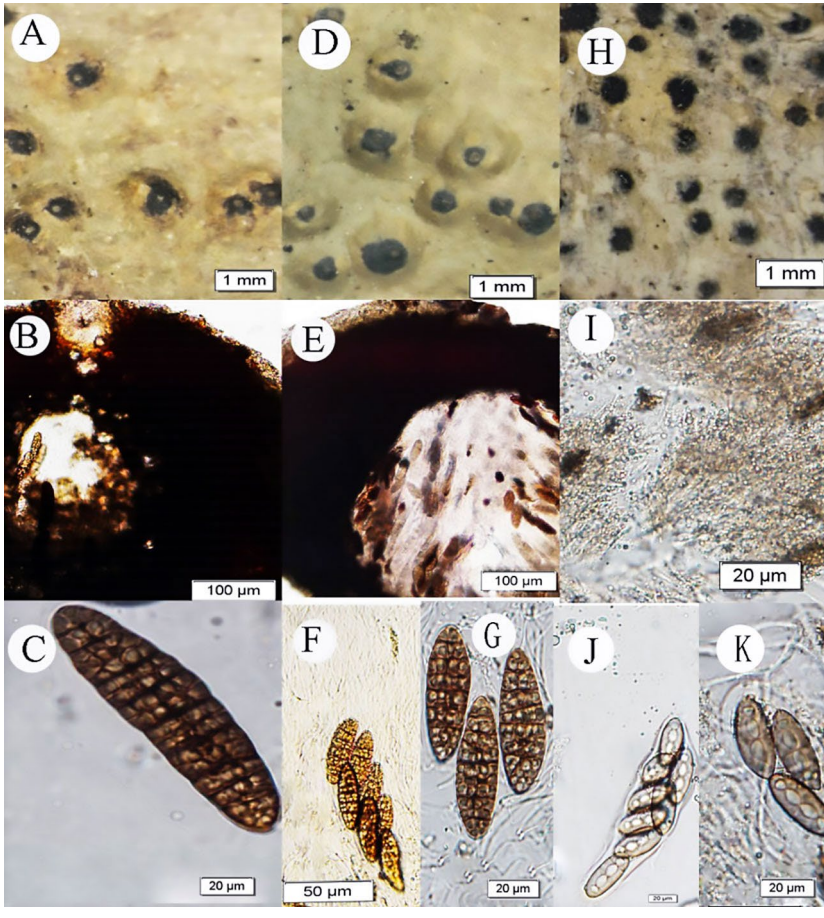

Fig. 2 ***Pyrenula duplicans*** (20160698, SDNU). A: thallus with ascomata; B: transverse section through ascoma; C: ascospore. ***Pyrenula pyrenuloides*** (20102817, SDNU). D: thallus with ascomata; E: transverse section through ascoma; F: ascus with ascospores; G: ascospores. ***Pyrenula subelliptica*** (20103054, SDNU). H: thallus with ascomata; I: inspersed hamathecium; J: ascus with 8 ascospores; K: ascospores. Scale bars: A, D, H = 1 mm; B, E = 100 µm; F = 50 µm; C, G, I – K = 20 µm.

Specimens examined: **China. Guizhou, Leishan,** Mt. Leigongshan, alt. 2178 m, on bark, 1 Nov. 2009, Z.T. Zhao 20103054 (SDNU). Jiangxi, Jian, Qianmo village, alt. 1300 m, on bark, 1 Nov. 2010, D.F. Jiang 20106232 (SDNU).

Distribution—India, North America, Russia (Jagadeesh & Sinha 2010, Harris 1989, Urbanavichene & Urbanavichus 2016). New to China.

Comments—*Pyrenula subelliptica* is characterized by the apical ostiole, inspersed hamathecium, distoseptate ascospores with three septa, terminal lumina separated from the exospore by an endospore layer, and strongly elongated central lumina. Our Chinese specimens are closely similar to the protologue description, except that the holotype has a non-inspersed hamathecium (Jagadeesh & Sinha 2010).

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